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ABSTRACT

If the intellectual norms and values embedded in the mathematics education reform movement are to move beyond individual classrooms and significantly influence entire schools and districts, school and district administrators will need to become centrally rather than peripherally involved. This paper discusses the way in which administrators' ideas about the nature of mathematics, learning, teaching, and school culture affect their interpretations of the nature and intent of the mathematics reform movement and their thoughts on how they might support it. In particular, administrators' views of parents' concerns, professional development for teachers, and how new ideas move around in a school are discussed. It is suggested that administrators have well-formed ideas about mathematics, learning, and teaching, and that these ideas influence their views of reform and how to provide support. Contains 28 references. (Author)

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CENTER FOR THE DEVELOPMENT OF TEACHING
PAPER SERIES

Lenses on Learning

How Administrators' Ideas about Mathematics, Learning, and Teaching Influence Their Approaches to Action in an Era of Reform

Barbara Scott Nelson

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Lenses on Learning

How Administrators' Ideas about Mathematics, Learning, and Teaching Influence Their Approaches to Action in an Era of Reform

Barbara Scott Nelson

If the intellectual norms and values embedded in the mathematics education reform movement are to move beyond individual classrooms and significantly influence entire schools and districts, school and district administrators will need to become centrally, rather than peripherally, involved. This paper discusses the way that administrators' ideas about the nature of mathematics, learning, teaching, and school culture affect their interpretations of the nature and intent of the mathematics reform movement and their thoughts about how they might support it. In particular, administrators' views of parents' concerns, professional development for teachers, and how new ideas move around in a school are discussed. I suggest that administrators have well-formed ideas about mathematics, learning, and teaching, and that these ideas influence their views of reform and how to provide support. These ideas need to be taken into account if administrators are to be central actors in reform.

If the norms and values embedded in the current mathematics education reform movement are to become a permanent part of school life, there will need to be not only large-scale change in the nature of mathematics instruction but also a virtual "reculturing" of school (Fullan, 1993). The implications of the vision of the National Council of Teachers of Mathematics (NCTM) *Standards* go far beyond what

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would result if many individual classrooms changed, one by one. Rather, they imply a new intellectual culture for schools—a culture that legitimizes and supports curiosity and challenge as the engines of learning, continuous exploration of mathematics and mathematical thinking on the part of both students and teachers, an orientation of reflection toward one's teaching and children's learning, and intellectual collegiality among teachers and between teachers and administrators. That is, not only will it be necessary for teachers to reinvent mathematics instruction from within a new conceptual frame; it also will be necessary for teachers and administrators together to reinvent school culture from within a new conceptual frame (cf. Nolan & Francis, 1992; Fullan, 1993; Lord, 1994; Elmore, 1996).

If reform efforts aim for change in the intellectual culture of the school, school and district administrators become central actors in the drama, not just members of the cast who could support teachers' efforts to change, were they so inclined. If mathematics education reform is to succeed, it will not be enough for administrators to support teachers' enrollment in professional development activities, purchase progressive curricula, and help parents understand why it is okay if math homework takes the form of measuring the living room rather than filling out a worksheet. Rather, many administrators will need to develop a new sense of what it means to understand mathematics, and what teachers are trying to achieve in their classrooms. Administrators will need to internalize a new set of intellectual values to guide them in setting the tone for their schools and districts and in developing policies and procedures that can instantiate the new intellectual culture. In order to do this, they will need to understand what it means for a child or a teacher to struggle to understand something that is very important and yet difficult, and what kind of school culture and climate would support them in that effort. Administrators will need to understand not only that classrooms may look and sound less orderly than before, but also where the new, underlying, intellectual order comes from.

American schooling is notoriously resistant to the kinds of fundamental changes in its core values and practices that are implied by the current mathematics education reform movement (Cohen, 1995; Cuban, 1984; Elmore, 1996; Tyack & Tobin, 1994). Although the scholarly and practitioner communities recognize that the views and inclinations of building and district administrators are critical to change efforts (cf. Elmore & McLaughlin, 1988), there is as yet little research on the nature of the conceptual changes for administrators that are implied by the current, standards-based reform movement. Only a few papers on the changed nature of teacher supervision and on school restructuring treat these issues as involving conceptual change for administrators (Nolan & Francis, 1992; Murphy, 1994; Murphy & Seashore, 1994). Just what kind of task would it be for administrators to take seriously the larger, cultural change agenda implied by the *Standards*? What resources do they bring to the task? What would support their efforts to learn?

In order to begin addressing these questions, this paper describes how a group of administrators, who wanted these reforms for their schools and districts, grappled with ideas about learning, teaching, mathematics, and the intellectual culture of school. The paper describes the work that these administrators did in a year-long inquiry group, and analyzes the core beliefs and values about mathematics, learning, teaching, and the intellectual culture of school that emerged in the course of that work. It goes on to describe how administrators' views about these matters influenced the way they interpreted the nature and intent of the mathematics education reform movement and identified actions they might take to support it. The paper examines how administrators' ideas affected their views of action in three domains relevant to reform: (1) interpreting and responding to parents' concerns; (2) providing professional development for teachers; and (3) encouraging the movement of ideas around a school or district.

I maintain that, just as students enter classrooms with complex mathematical ideas in place, and teachers join professional development programs with well-formed ideas about learning and teaching, administrators come to this work with ideas about the nature of mathematics, learning, teaching, and their role in supporting a particular intellectual school cul-

ture—ideas that have served them well in their careers and have been reinforced by their evident success as guides to action. These ideas cannot be ignored. Moving forward necessarily entails helping students, teachers, and, in this case, administrators to reflect on their ideas and examine their efficacy in the light of new data and experiences. I show that the character of administrators' ideas about the nature of mathematics, learning and teaching, and school culture influences their orientation toward three practical tasks associated with reform, suggesting that paying attention to administrators' ideas is an important step in the process of reform.

Methodology

Context of the Work

The work described in this paper took place in the context of a systemically-embedded teacher enhancement project, Mathematics for Tomorrow (MFT), funded by the National Science Foundation.[1] Participants were school-based teams of teachers and principals, together with their respective district-level administrators, from three districts in the metropolitan Boston area. Fifteen school and district administrators participated in the program: nine elementary-school principals, three district-level elementary mathematics coordinators or supervisors, and three assistant superintendents of curriculum and instruction. One administrator in the group was concurrently a high school mathematics teacher. The others had little formal mathematics training, although the elementary principals had taught mathematics as part of their elementary-school teaching experience. Two administrators had PhD degrees in liberal arts subjects, and most had masters degrees in education. (Note that there may be significant differences between the ways that elementary and secondary schools regard reculturing. This paper treats elementary- and middle-school education only.)

MFT focused on the administrators' own practice and how it might support mathematics education reform. Project staff conducted a monthly seminar, or "inquiry group," for discussion of issues that concerned the administrators about their own practice. For these evening meetings, project staff assigned readings, developed activities, and facilitated group discussions to give administrators the opportunity to more deeply examine their fundamental ideas about mathematics, learning and teaching, and the intellectual culture of schools. (For a syllabus of the Administrators' Inquiry Group, see the appendix.)

The project staff intended these discussions to encourage administrators to articulate and examine their own understandings of learning, teaching, mathematics, and school culture—ideas that many administrators had had for so many years that they functioned as assumptions and were no longer critically examined. The project's goal was to promote administrators' reflection on the degree to which those ideas were helpful guides for practice in the current reform climate. To encourage this reflection, project staff hoped to develop a culture of inquiry among the administrators, in which participants and facilitators would think together about important issues related to administrators' practice. In the design and facilitation of the administrators' inquiry group, staff adapted the same theoretical position that underlies MFT's work with teachers (Schifter & Fosnot, 1993; Nelson & Hammerman, 1996), namely, that the goal of activities and discussions should be to provide participants with the opportunity to encounter new ideas about mathematics, learning, and teaching. Such new experiences and ideas often challenge older ones, creating temporary conflict and confusion that needs to be worked through before a resolution emerges and new ideas are in place.

For example, by viewing videotapes of clinical interviews and examining student work, administrators began to see that children's mathematical thinking is complex and nuanced. By exploring mathematical topics until they really made sense, administrators gained a qualitatively different appreciation of what it might mean to "know" mathematics. By examining excerpts from teachers' journals in which teachers recorded their experiences of trying to change their ideas and their teaching, administrators achieved new understandings of teacher development.

Thus, participants in the inquiry group were challenged to develop new understandings of fundamental concepts. Further, by being part of a community in which ideas were being built collectively, administrators experienced, often for the first time, what collegial learning—and classrooms—could feel like (Nelson & Hammerman, 1996; Schifter & Fosnot, 1993).

Data Collection and Analysis

Ethnographic field notes were taken at all administrator inquiry group meetings. These meetings were also audiotaped, and the tapes were transcribed. In-depth interviews were conducted with all administrative participants at the beginning of the program; interviews with two "focus" administrators were conducted periodically during the second year. Site visits were made to the two "focus" administrators' workplaces and field notes were taken on these visits. The data analyzed for this paper consisted of transcriptions of the audiotapes of seminar meetings and transcripts of all interviews with administrators.

The data was passed through two phases of coding. First, I identified administrators' ideas about mathematics, learning and teaching, and the intellectual culture of school. This coding scheme was indicated by the theoretical perspective that underlay the design of the inquiry group. That is, it operated from the hypothesis that administrators' ideas about mathematics, learning and teaching, and the intellectual culture of school would vary over a continuum from traditional to constructivist. Because I was interested in the relationship between administrators' ideas and their administrative practice, the second round of coding identified the practical arenas that seemed most salient to the administrators, from which several emerged. The three for which I found the most data—hearing and responding to parents' concerns, providing professional development for teachers, and encouraging the movement of ideas around a school or district—were selected for further analysis. I then sorted the data further to identify the relationships between two sets of administrators' ideas: those about mathematics, learning, teaching, and the intellectual culture of school, and those about action in each of the three practical arenas.

Context of This Paper

This paper is the first in a set of three that my colleagues and I plan to write about our work with administrators. The purpose of this first paper is simply to suggest that, in the reform context, administrators' ideas count. After all, administrators *have* ideas about mathematics, learning, and teaching, some of which are in agreement with fundamental assumptions that underlie reform, some of which are not. The second paper will focus on new forms of administrative practice created by some administrators in their schools and districts, and on the interplay between changes in their thinking and changes in their action, using the domain of curriculum policy as a case. The third paper will describe the pedagogy used with the administrators' group; it will outline the theory behind the design of the inquiry group, describe the techniques we developed to apply the theory, and analyze what worked and what didn't work in our efforts to help administrators learn.

During the project, staff took a normative stance with regard to administrators' ideas. If the intellectual culture of schools and districts was to be coherent, we believed, it would be necessary for administrators to develop ideas about mathematics, learning, and teaching that were consistent with those that the teachers were developing. Therefore, we tried to provide opportunities for administrators to consider positions that would be consistent with a socioconstructivist view of the nature of knowledge and learning. Later papers will detail the development of administrators' thought, the nature of the change process, and the design of the inquiry group itself. This paper's purpose is to represent accurately the several major positions that administrators expressed, and the relation of those positions to courses of action that administrators thought it appropriate to take, in order to describe the range of ideas we found among this group of administrators. (Even from the normative perspective of our project, it was important to understand and respect all positions, in order to help administrators move *away from* them, if they chose.) The purpose here is to paint a picture of administrators' thought as vivid, grounded in particulars, and moving fluidly, and to suggest that for admin-

istrators, as well as for students and teachers, thought, interpretation, and action are intimately interwoven.

Because the period of time in which the data for this paper was collected coincided with the period in which we were trying to help administrators change, our data does, indeed, show change in the ideas of many administrators. It also indicates the development of a group culture over time. These changes are mentioned from time to time in this paper, wherever it becomes appropriate to do so in order for the reader to understand the context of the discussion.

What Kinds of Ideas Are at Issue?

Contemporary ideas about reform in mathematics education are undergirded by a new conception of the nature of knowledge itself (NCTM, 1989; NCTM, 1991), a socioconstructivist view. Knowledge is considered to be the dynamic and conditional product of individuals working in intellectual communities, not a fixed body of immutable facts and procedures. Learning proceeds through the individual's construction of understanding, not by accepting facts and rules from teacher or textbook; teaching is the facilitation of knowledge construction, not the delivery of information or the opportunities for practice.

The implications of these views about knowledge, learning, and teaching for the practice of teaching have been the subject of considerable intervention and research in recent years (Fennema et al. in press; Fennema & Nelson, in press; Schifter & Fosnot, 1993; Wood et al., 1991). Because of the way they themselves were educated, many teachers developing a practice that incorporates these views cannot accomplish it simply by adding new techniques to their current ideas about teaching and learning. Rather, they require an epistemological shift—changing their beliefs about the nature of knowledge and learning, deepening and expanding their knowledge of the subject they teach, and reinventing their classroom practice from within the new conceptual frame.

Studies of teachers in the process of changing their teaching to support children's construction of mathematical knowledge indicate that many teachers start out with the following beliefs:

- that students are "empty vessels" waiting to be filled. This belief eventually evolves toward a belief that students are intellectually generative, with great capacity to pose their own questions and develop their own solutions to problems.
- that students learn by being told what to do and how to do it. This evolves toward confidence that students will learn through their own effort and can take greater responsibility for their own learning.
- that mathematics consists of a series of isolated facts and topics that should be taught in a certain order. This belief evolves toward a view of mathematics as a flexible network of ideas, with many interconnections, which can be approached in a variety of ways.
- that instruction should follow the textbook and that the teacher's responsibility is to cover the material. This evolves toward the belief that instruction should build on what students know and can do, and focus on important questions and ideas in the field.

(Carpenter et al., 1988; Fennema et al., in press; Lampert, 1987; Schifter & Fosnot, 1993; Schifter & Simon, 1992; Thompson, 1991; Wasley, 1991).

Several years of work with teachers on the project of transforming their teaching has led teacher educators and researchers to conclude that conceptual change is an essential part of the process—teachers must reconceptualize the nature of learning, teaching, and subject-matter knowledge as part of the process of transforming their teaching (Fennema et al., in press).

While our knowledge about administrators is less developed than is our knowledge about teachers, it is likely that many administrators, too, will need to deeply examine their ideas about the nature of knowledge, learning, and teaching if they are to take action in support of the mathematics education reform movement. Like teachers, administrators hold beliefs about mathematics, learning, and teaching that can be characterized according to different views about the nature of knowledge. These views also influence their beliefs about school culture.

Like many teachers, a large proportion of today's administrators were educated at a time when mathematics was viewed as an assemblage of facts and procedures, learning as the process of absorbing new information and practicing new skills, teaching as the transmission of accumulated knowledge and providing students the opportunity to practice new skills, and classrooms as places where students work, by and large, individually. Some administrators in our project held views that fell squarely in this more traditional camp, while others had views that were more socioconstructivist in nature. A number of administrators held mixed positions—combinations of transmission and socioconstructivist views. Within the socioconstructivist position, administrators sometimes had subtly different perspectives. These subtleties will be indicated in the paper when they occur.

Common views of mathematics, learning and teaching, and school culture that were present in the group are sketched below.

Mathematics. One perception of mathematics present in the group was that it is a system of rules and procedures that allow efficient problem-solving. From this point of view, administrators felt that an important goal of elementary mathematics instruction should be mastery of the number facts and the algorithms. These were seen as fundamental building blocks—tools to be used on the more difficult conceptual tasks that students would encounter later. Some administrators held a qualitatively different view of mathematics: that it is a system of ideas that can be understood—a system that has pattern and a beauty of its own. While it has its functional side, in this view, mathematics is one of the liberal arts—a way to know, a way to use one's mind that is intrinsically interesting and pleasurable. As a system of ideas, mathematics is a way of thinking that develops in a child, over time, through interaction with the world, including the use of materials, such as manipulatives, that can be made available in classrooms.

Teaching and learning. Administrators' views of the nature of learning and teaching also varied; these informed their understanding of teacher learning and, therefore, the character of effective professional development. One line of thinking held that learning in general (including teacher learning) is a matter of absorbing new information and practicing new techniques. In this view, teaching is the skillful representation of information and the construction of opportunities for practice. Another view was that student or teacher learning often involves a change in beliefs or a fundamental conceptual change. That is, often learning is not a matter of absorbing new information into a set conceptual frame, but rather involves changing the conceptual frame itself. Administrators of this opinion often characterized the experience of this kind of learning by confusion, puzzlement, and discontinuities. In this view, teaching means providing intellectually rich learning environments and complex tasks that will carry students (or teachers) into those environments.

The intellectual culture of school. The administrators in our group also held a range of views about the intellectual culture of schools, views that informed their sense of how new ideas could come into a school and move around easily. These views were closely related to their ideas about the nature of knowledge itself.

In one view, knowledge is a discrete "chunk" that can be passed from one teacher to another. In this view, the process by which ideas move around in a school is one in which teachers share or tell each other about new, effective practices. There seemed to be agreement among some administrators about good techniques for doing this kind of sharing. For example, they believed it is important for teachers to "feel ownership" of ideas, even if this requires teachers to recreate the ideas for themselves. Other administrators held a qualitatively different position: that knowledge is built by a community of inquiring people. This position indicates a view that the process by which ideas move around a school is one of collective inquiry into shared problems or puzzles, on the part of principals as well as teachers. This view holds that what is to be shared is not "chunks" of knowledge or specific teaching techniques, but questions—about how children learn, how ideas develop in children's minds, and about such pedagogical issues as how to handle a highly heterogeneous classroom.

Associated with these perspectives were two different views of the nature of the school community—that it is a group of people who come together to execute the technical tasks of knowledge transmission, or that it consists of people who have developed bonds of trust among each other, which can support the sharing of difficult dilemmas. These different views about knowledge and community imply different views about the intellectual culture of school—should it support the efficient transmission of knowledge, or should it support the messy and uncertain process of inquiry?

These different understandings of mathematical knowledge, learning, teaching, and school culture functioned as lenses through which our administrators interpreted the nature and demands of the mathematics education reform movement.[2] These lenses shaped how administrators interpreted the queries and worries of parents, understood the nature of professional development for teachers, and thought about how new ideas might move around in a school or district. These lenses also informed the practical judgments (Nussbaum, 1990) that administrators made about how they themselves might act to encourage reform. However, as their ideas changed, administrators discovered new avenues of action for themselves, their schools, and the teachers with whom they worked.

Administrators' Beliefs, Interpretations of Reform, and Thoughts about Practical Action

Interpreting Parents' Concerns

If mathematics education reform is to be truly accepted and implemented in the nation's schools, it must, in the final analysis, be embraced by parents, who must have confidence that schools are providing an adequate mathematics education for their children. Administrators are continually alert to the concerns of parents in their schools and districts. As public servants, administrators feel keenly the need to satisfy parent constituents—a difficult job, given the increasing pluralism that characterizes many communities. Furthermore, administrators are accustomed to balancing the tension between what parents seem to want for their children and what they, as professional educators, think is best practice. The mathematics education reform movement has delivered a particular form of these classic issues to administrators, and the administrators in our group were most interested in talking with each other about how to interpret and handle parents' concerns.

Their own ideas about the nature of mathematical knowledge equipped our administrators to hear quite a variety of different things in the worries of parents, to ask quite different questions about the meaning of the mathematics education reform movement, and to approach the task of engaging in mathematics education reform in their schools in quite different ways. One view—that mathematics is hierarchical, with "higher-order" skills built on basic ones—led administrators to agree with parents that facts and algorithms should be taught explicitly and first, with conceptual learning to follow. Another view—that mathematics is a system of ideas that children develop over time—led administrators to sympathize with parents' concerns about the learning of facts and skills, but then to educate them about the nature of mathematical knowledge. One administrator, who viewed mathematics as hierarchical, put it this way:

> It seems to me that no child will be able to solve complex math problems without knowing the fundamentals of math. Correct me if I'm wrong... [W]e can talk about getting students to be able to use foreign languages in creative and complex ways to express their own thoughts... [but t]hey will never be able to do that unless they know vocabulary and verb conjugations, or whatever the building blocks are.

The view of mathematics as hierarchically structured, with basic facts and skills forming the bedrock upon which problem-solving and conceptual knowledge can be built, was a very powerful force in the lives of these administrators. It had both great plausibility and the weight of the many years of their own school mathematics education. It also provided a context for interpreting parents' expectations for mathematics education. Some parents, too, it seemed, held the hierarchical view and expected the schools to teach basic facts and procedures first, and explicitly. One administrator explained that, for such parents, the foundations

of mathematical knowledge were not conceptual understanding but command of the number facts and algorithms, such as the multiplication tables:

> It seems to me that with the parents that we were with last night, that if they felt that if their kids had a solid foundation of mathematics, that they could whip 'em off—nine eights are seventy-two—without ever having to think about it, then they would like the idea of kids delving into mathematical thinking and using it in ways that are meaningful to them. They'd love that. I think that they want the underpinnings there and they want to see evidence of those underpinnings.

In the view of such parents, if children hadn't memorized the number facts they were not being taught properly. As one administrator put it,

> If you have a parent... who says, "My kid is not learning the basic skills that a child needs to move on and I'm not willing to wait. I want those skills now. I want to see them incorporated into the everyday process that the child is doing"... That's the heart of it. When parents complain about math they generally complain that their kids don't know their facts and they're sitting around counting on their fingers because nobody is teaching them ... Parents are very apt to say, I know how you learn math. You memorize the facts, and then start applying them to problems.

When administrators themselves held the view that mathematical knowledge is hierarchical, with command of basic facts and algorithms coming first, parents' demands for instruction in skills and facts seemed reasonable. In the face of such expectations, these administrators believed the best course of action to be to adjust mathematics instruction to meet the expectations by melding instruction that focused on conceptual development with practice on math facts.

> One would hope that [conceptual development and drill and practice] would support each other. Worksheets would give additional practice to the kids that would enhance what they're doing and enhance what the teacher is trying to achieve. I think that would be the ideal solution in this particular instance.

In an effort to provide administrators with the opportunity to consider other views, our inquiry group discussed the view that mathematical knowledge is built by each child. To provide an example, project staff described research on the development of children's mathematical thinking that showed that counting on their fingers or using concrete objects was a form of modeling an addition or subtraction problem; and that, often, the arithmetic algorithms taught in school do not match children's natural ways of solving problems and thus contribute to a disconnect between children's understanding of mathematical ideas and school mathematics (Carpenter, 1985). This troubled one administrator. She asked if reform meant not teaching the multiplication tables and, if this were the case, she thought that moving down the path of reform would inevitably put her in conflict with parents who went to school in the same era that she did:

> Talking about kids using fingers as an algorithm makes parents crazy. At least parents my age. 'Cause that was an absolute "no-no." You were really dumb if you had to use your fingers. So, is it an absolute taboo to teach kids to whip off the [multiplication] tables?

Several administrators who held the hierarchical view puzzled over this one. *Was* the mathematics reform movement making it taboo to teach children to "whip off the multiplication tables?" For some it seemed to be an either/or situation. Either teach math facts and skills and not engage in mathematics education reform, or engage in reform and let children's understanding develop as it would. They did not see a middle position: that if children had a lot of experience exploring numbers in multiplicative relations, the facts of multiplication might emerge quite sensibly. For some administrators, teaching the facts and tables came first, and a mathematics education reform movement that seemed to say otherwise didn't make sense to them—and put them in a very difficult position vis-à-vis parental perspectives and concerns.

Another administrator noted that she had come to see mathematics as a liberal art—as a way to know and think. In explaining this, she referred to a mathematics session in the inquiry group in which the administrators had explored the relation between area and perimeter by figuring out

how many tables would be needed to seat different numbers of people at a banquet (Shroyer & Fitzgerald, 1986):

> There's a beauty in seeing something that was merely functional be something aesthetically beautiful and honest, in itself. [The mathematics we do in this program] isn't about cubes and things, although I like that—it's fun.... What did we design one day, tables for banquets? What you've helped me to see is math as math, math as system, math as epistemology [as a way to know].

But she did not think this view was shared by the parents in her district. Rather, to her understanding, parents viewed mathematics as instrumental, as a way for their children to reach a larger educational goal:

> My experience with parents is that math is supposed to get you somewhere—it is a ticket, period. If you are an unusual child it will help you get somewhere actually using math (e.g., being an architect, engineer, mathematician) but for most people, it gets you into college, it gets you an SAT score. Math is a... ticket.... It is not even negotiable with most parents, I've found, that math is anything [other than a ticket]. Except for the very, very few who see it aesthetically and imaginatively and perhaps even as a liberal study. But very few do.

Her new understanding of math as a liberal art gave her a way to describe mathematics education reform to these parents. She said that it was her job to help parents see that their children would benefit from an education that was mathematically deeper and more rigorous, not withstanding their interest in math as a ticket. It was her job, she said, to help them understand that reformed mathematics education was not necessarily more efficient, but that it was more enduring. She planned to explain the similarity between prospective changes in mathematics education and the whole-language movement, with which parents were familiar. And she noted that she would search for familiar metaphors through which parents could understand that their own long-standing familiarity with a particular tradition of mathematics education might make it difficult for them to imagine the nature and value of reforms in mathematics education:

> Oh, yeah, [parents have] lots of concerns. But, that's my job, that's my job. It entails a lot of things at once: Giving them the sense of [the similarities between th: :ransition [process] in whole language and math. And... to say it is not more efficient (because a lot of the promises that we make for programs are based on efficiency). I think I would say right away that it's not efficient.... [And I] have to show them that I believe that it's right and that it's more powerful and that it [has] more long-lasting impact. It does have more enduring power for kids, because they've learned something deeper. And I always try to compare it to something that they understand. It's something like, well, before you were a parent you didn't really understand what [parenthood] was like...

Still another view of mathematical thinking represented in the inquiry group was that it develops in children over time, through the exploration of numbers and their relations in a variety of ways. One administrator who held this position thought that parents' overall goals for their children's mathematics learning would be met through such explorations, though parents might not understand that:

> [The parent] thinks learning [mathematical concepts] several ways is taking a whole lot more time... [But] it isn't a race... I think [we need to] make visible how, over time, that kind of exploration deepens the understanding. We might actually find out it is very efficient.

This administrator felt that it was important not to react to parents' fear, or simply to reassure them, but actually to show parents how children's mathematical thought develops and to help them see that whatever their child can do today is a precursor for what the child will be able to do tomorrow:

> That's why it's our responsibility not to be reactive.... I think it's good for parents... to look at videos, children's exhibitions, whatever ways we make [children's thinking] visible.... And we're always wanting the parent to understand in this moment what it is that we have come to understand over too many years. That's the worry of parents—[as the parents of a third grader] they don't see beyond age eight yet.

This administrator took parents' concerns very seriously but was less likely to accept their instructional expectations. Because she could see that there was something parents did not understand about children's learning, she could be sympathetic to their worry, but also see that

educating them about the nature of children's thinking was one of her responsibilities.

Ideas about Professional Development.

If administrators are to make and enact professional development policies for their schools and districts that will move mathematics instruction forward, and if they are to support teachers who are working to change their practice, then their views of what teachers are trying to do in their classrooms—and the nature of effective professional development—are quite significant. What is it that teachers need to know and know how to do? What kinds of experiences are most stimulating and useful for teacher learning? How long does it take for teachers to make substantial changes in their instructional practice? What are the essential characteristics of professional development that can help teachers make these changes? For which teachers is this form of professional development most appropriate? These were important topics of exploration and discussion in the inquiry group.

Administrators' views of the nature of learning and, in particular, of the kind of learning that teachers would need to undertake to change their teaching in the direction suggested by the mathematics education reform movement, had implications for their orientation toward the provision of professional development resources in schools and districts.

Several different positions on this matter were evident in the group. One position, characterized by a "transmission view" of learning, interpreted the mathematics education reform movement as largely requiring the learning of new techniques and skills, and so professional development for teachers would be adequate if it provided that learning. In another position, conceptual change needed to happen, including opportunities for teachers to question and rebuild older beliefs, knowledge, and practice. From this point of view, professional development programs for teachers would need to extend over some duration; help teachers deal with beliefs about learning, teaching, and subject-matter knowledge as well as techniques; and provide support for teachers who found such exploration challenging. However, there were subtle differences among administrators about how this conceptual change process worked. According to some, teachers might move gradually from professional development programs aimed at helping them open up their instruction toward programs emphasizing reconceptualization; others believed that reconceptualization is essential and primary. The various positions, and views within positions, have very different implications for the design of professional development policies and programs for districts and schools.

In the transmission position, the teaching advocated by the mathematics education reform movement was not understood as fundamentally different from what many teachers were accustomed to. That is, it was not seen as a form of teaching that would require the development of deeper mathematics knowledge or change in basic beliefs about mathematics, learning, and teaching. Rather, what the mathematics education reform movement seemed to require of teachers was to learn about and practice new techniques—how to set up and manage cooperative learning groups, how to have children voice their mathematical ideas in the classroom, how to ask open-ended questions, and so on. From this position on the nature of reformed teaching, it would suffice to give teachers opportunities to learn about and practice these new techniques. As an example of this kind of learning, one administrator cited how teachers learn to use calculators:

> I can think of times when, for example, people get new calculators [for their classrooms] and they want to know how the calculator works. This is what you do. You sit down and get told how to use the calculator. That's the model we want for that. And there are certain things that work that way.

According to this position, the most useful kinds of professional development programs in a district would be those that could acquaint teachers with new ideas and give them opportunities to practice new skills.

In the "conceptual-change" position, on the other hand, important conceptual learning would be necessary for the substantial reform of teaching envisioned by the mathematics education reform movement. But there were at least two different views within this position about how this might happen, essentially represent-

ing the argument about whether change in practice or change in beliefs comes first. There is evidence that changes in both belief and practice are necessary for the kinds of change in instruction that are at issue in this mathematics education reform movement, and that such changes are iterative (Goldsmith & Schifter, in press). Further, there is evidence that changes in belief need to precede changes in practice (Schifter & Fosnot, 1993) and also evidence that in some cases changes in practice can "jump start" the process (Franke et al., in press). From the latter point of view, teachers who implement new practices in their classrooms may observe unexpected mathematical thinking on the part of their students. Puzzling about this may lead teachers to question their prior beliefs about the nature of mathematics learning.

The administrators in our program played out this argument. One administrator argued the position that, while conceptual change was necessary, change in practice could precede change in beliefs; for some teachers, this was the place to start. For example, some teachers began their own change process by participating in MSAP, a pseudonymic interdisciplinary math and science professional development program that offers teachers the opportunity to explore the possibilities for hands-on, activity-based instruction in their classrooms:

> If you want to get everyone from A to Z, people [will start in different places]. Some people would much rather go to an MSAP workshop than be [at EDC], because it is uncomfortable [here at EDC].... I don't want them to do an MSAP their whole life, but [I am pleased] if that gets their feet wet,... gets them going, and gets them to be comfortable and to start working, and then begin to grapple with some of the things... that they would be grappling with [here].

For this administrator, it was desirable for the district to have access to a range of professional development programs, in order to match teachers' needs with appropriate professional development opportunities. She saw herself as a "triage officer," with the responsibility to take best advantage of limited opportunities to provide conceptually-oriented professional development:

> I want to get everyone to be able to go through the kinds of intensive training that we have them do here [at EDC].... I am a triage officer. We only have a certain number of people who can get in [these innovative professional development programs] and we want to get people in there who can hit the road running and become lead teachers.

Alternatively, for those who feel that changes in belief precede changes in practice, the kind of teaching suggested by the mathematics education reform movement is seen as qualitatively different than what most teachers are accustomed to, and requires substantial relearning on the part of most. Such relearning is *essentially* internally generated and problematic. It would not be adequately supported by the acquisition of new techniques or the experience of doing activity-based instruction in one's classroom. Rather, it *starts* with conceptual change on the part of the teacher.

An administrator of this persuasion tended to view all teachers' learning through this lens, searching for the set of experiences—the enabling conditions—that would motivate each one. For example, this administrator told how she tried for years to encourage a teacher to use writing in her classroom. Finally, apparently spontaneously, the teacher took interest in the issue and began investigating what it would mean to do more writing in her classroom:

> There is a teacher in my school—well, we've been talking about her classroom doing writing for years. And yet, she wasn't actually doing writing until she reengaged. I was surprised she even volunteered for this project. And I think about how many times we have had start-ups and stops, with this particular teacher. But it appears so deep right now, it just appears that she is asking more questions and spending more time than ever before, and it's like, something got unlocked inside this woman, and she's maybe two years from retirement. I don't know. But it's just so wonderful when it happens and I think it's just finding the right conditions that really allow... I don't know, she's just totally engaged.

This administrator acknowledged that a significant amount of time is necessary for change; she continued to search for the key to reconceptualization for each teacher, in spite of their

discomfort and resistance. She spoke explicitly of her responsibility to find the right way to reach each teacher:

> It's hard for us who are in supportive roles to see people taking detours when we really think we might know better. But I really think that creating conditions that help people find their own way is really ultimately going to be... stronger. I think it's just finding the right conditions. And I think that's our job. To figure out how to do that.

Such basic differences in orientation toward the nature of teacher learning guided administrators' images of the range of professional development experiences that a district should offer; the kinds of things that teachers need to learn—and can learn—from various professional development activities; and what teachers should be encouraged to try to do in professional development programs.

During the course of the inquiry group, most administrators came to see a role for conceptual change in teacher learning, and developed images of a potential professional development project that aims at reconceptualization. Their images have important implications for the criteria administrators might develop to guide the design of professional development in their schools and districts. Most came to see that professional development oriented toward conceptual change should focus on teachers' beliefs, give teachers the opportunity to base ideas about change on actual classroom experience, and provide teachers the opportunity to experience inquiry-based learning themselves. One administrator clearly stated her conviction that, if they are to change their teaching significantly, teachers' beliefs about the nature of learning matter:

> [Teachers] have to... believe more than understand, that the new way will help their kids better than the old way. I think they don't have to have it here [points to her head], they have to have it here [points to her heart].... I think it has to be a deep, deep belief for teachers to change, because teachers really want to help kids. Once they believe it here, by seeing it, I think it's easier for them to change. Not faster, but easier.

Some administrators also saw that the impetus for teachers to examine their beliefs and perhaps change their practice was grounded in what they observed in their classrooms. One administrator expressed this in terms of the story of "Kathy," in a case study that the group read.

> When we change our practice, it's because we've seen children at the same developmental level try and fail, try with some success, try with more success, try with long-term success, try with some short-term success, using all these methods.... Sort of like a fast-forward, when you see a flower. The bud is closed, and it opens and opens, and then it decays.... This is what Kathy saw... and she decided she needed to plant another seed.

By the end of the inquiry group sessions, several administrators saw that each teacher would extend his or her own mathematical and pedagogical understanding from interaction with the environment, and that the pedagogical design of professional development experiences for teachers can be analogous to the pedagogical design of classrooms. One administrator recalled the process by which teachers and administrators at an all-day MFT workshop had explored the geometry of circles and cones by making witches' hats out of construction paper and tutus out of tulle. She described the kind of learning that resulted, its relationship to the kind of learning that could happen in mathematics classrooms, and noted the futility of the transmission mode for achieving this kind of learning. First, she described the workshop:

> When I came to [that workshop in which] teachers... were making tutus or witches hats. I mean, there is a process. Everybody sits down and goes through this process. And I get all frustrated and keep cutting smaller. I mean, you go through this process and then you come out the other end.

She continued by noting that exploration of the geometric ideas embedded in the activities wasn't complete at the end of the workshop. She noted that participants worked on these ideas after the initial event and ended up in different conceptual places:

> I'm sure what happens after that is everybody goes home and some change [occurs].... I guess what I'm saying is when you've been through the process and you come up with the product, each person who's been in that process will translate it differently...

She described the parallel between the way the workshop for teachers was structured and the expectations for mathematics classrooms:

> And I think that it perfectly replicates a lot of the work that happens here, and in schools, and in classrooms. People always end up in different places, change will occur, and does occur, and it's often very positive, but it's going to mutate...

This administrator ended by contrasting this with how professional development conducted in the transmission mode would have looked, and what its results would have been:

> But... if you guys had stood up and said, "Okay, now, here's how you ought to do math from now on, get it now, get it up front, we're going to give it to you right now, this way. You take and you say to kids, think about this deeply and..." I mean, you could give us that on a silver platter, but you're not going to get change in the classroom until people have some kind of an immersion and rethinking and the opportunity to rethink this...

Not only was teachers' learning viewed as requiring immersion in an environment rich with opportunities to explore mathematical and pedagogical issues, it was also seen as deeply mathematical.

Another administrator spoke of how exciting it was for teachers to actually do the mathematics that they were teaching, so that they could help their students understand it:

> I think what I see teachers doing this work do, is they really get to the inside of what it is that they're teaching.... It's not a formula. Why it's happening, and how you get the kids to understand why it's happening,... people get excited by that. It's liberating, really, it's liberating when the way you've learned math has been formulaic.

Still another administrator saw that the professional development experiences provided for teachers also modeled what they would do in their classrooms with children:

> What [this] does is to replicate, on an adult level, what students are experiencing at their levels.... I think it asks the teacher to experience a different relationship to seeing a student be puzzled, or pleased, or worried, or... I think it's a good thing. I think this really is fresher, and more like what students experience. And I think that's a very good thing. To be a true learner.

One of the issues that deeply puzzled this group of administrators was how to interpret some teachers' reluctance to truly engage with professional development oriented toward helping them to examine underlying beliefs and reconceptualize fundamental ideas about mathematics, learning, and teaching. From the point of view of professional-development policy, this is a significant issue, since an administrator's stance on it has important implications for the kinds of professional development that will be offered and the circumstances in which teachers will be encouraged to participate.

From the perspective of administrators with the transmission view of learning—who viewed learning as an unproblematic process of continuous improvement—confusion and discomfort are to be avoided. An administrator with this position was likely to respect teachers' expressions of reluctance and discomfort and not push them toward professional development programs that would challenge their beliefs and encourage reconceptualization. One administrator expressed this point of view in terms of David Cohen's image of a teacher who had misplaced confidence in the depth and robustness of her mathematics knowledge and "was on thin ice but did not know it. She skated smoothly on with great confidence" (Cohen, as quoted in Lord, 1994). The administrator understood why a teacher might not want to engage in conceptually challenging professional development, and seemed willing to let that reluctance stand:

> I have problems with this one. If a person is skating along, and enjoying it, and getting over the inevitable lumps in the ice, there's not a heck of a lot of reason to try to be a hockey player....

The administrator who viewed activity-based learning and conceptual change as lying on a continuum took advantage of the existence of a range of available professional development programs to find one that didn't push any individual teacher too hard:

> I look at teachers the way I looked at students in my room. I had to figure out where they were and how I could move them forward. For some

> people it would be uncomfortable to be working in that [conceptual change] model. They felt discomfort, or suppressed, or whatever.

Another administrator in the project, while not sure that the strategy (of starting a teacher in the traditional, transmission paradigm of professional development and later moving the teacher toward another) would work, appreciated the practicality of accepting teachers where one found them in order to work with them at all:

> [S]he can take teachers wherever they are. And if they're in the prevailing view, she's gonna take them there because that gets them in a relationship and hopefully that relationship is going to move to a different paradigm. Maybe it is and maybe it isn't, but if you're not in the relationship, it's nowhere.

But those administrators who perceived that effective professional development requires fundamental conceptual change on the part of teachers, viewed discomfort and resistance as indicators that important ideas were being challenged. They were more likely to find ways to support teachers through that process than to back off and not support any professional development that might create confusion and discomfort. One administrator thought that teachers' reluctance to engage in challenging professional development might be allayed if one creates an environment that is safe for taking risks:

> The other thing that I think is just really central, just like it is for kids, is that it happens in an environment where there's a safety net and there's trust. I think it's our obligation, as people who think about professional development, to think about the ways in which we all learn, that give us a little bit of that safety net to take the risks, to be involved in something like this. I think that's an enabling condition.

Ideas about the Supports for Teacher Change and How Ideas Move around in a School

These administrators were very interested in figuring out how to increase the prevalence in their schools of subject-matter instructional reform in general, and reform of mathematics instruction in particular. Most understood that providing professional development experiences for individual teachers, one by one, would not be sufficient to ensure that new instructional practices would become a permanent part of school life. Rather, they saw that a different culture would need to obtain in schools, in which new ideas could come into the school and move around easily. They were interested in exploring the process by which new ideas are taken up by teachers and integrated into their practice, and the roles they might take in making that happen. They also explored the nature of collegiality among teachers, and between teachers and administrators, in a school.

Once again, their views about the nature of learning and teaching influenced how they thought about these things. One view was characterized by the older, transmission paradigm, which led to the belief that ideas can be made to move around in a school by having teachers tell each other about what worked. In the transmission paradigm, collegial help is technical in nature and can be offered by a variety of people. But, according to another view, learning involves internally-generated questions and conceptual uncertainty. In this view, the way to get ideas moving around in a school is to focus attention on asking and thinking about questions that genuinely matter to the people there. In this case, collegial help needs to include the empathy and support that comes from peers in a committed and sustaining group.

These two views have very different implications for the way ideas move around in a school, and different implications for the role of the principal.

One type of understanding that administrators had about how ideas move from one person to another in a school was very close to the paradigm of "telling" information to other people. For example, one administrator noted that principals could decide which issues should be worked on in a given year by the school as a whole; teachers could share their solutions to these problems, rather than only working on them individually in their classrooms. Her view of the nature of that sharing was that teachers would tell each other what they had discovered:

> Principals have to pick their battles.... I think this is a point where the principal should definitely say [to the teachers], "Now, we're all concerned about this, we've all been working on it at various levels, some of you have worked

> on it individually in your own classrooms, some people have worked in groups. Next time we meet, I've asked these three people to share with us one of the solutions they've come up with this year, and I encourage all of you to share, with me and with each other, whatever solutions you have. Every other month for the next year we're gonna look at all these solutions to see which ones will best apply, kind of universally, to help our problem."

This administrator clearly saw that teachers might have much to learn from each other and that important issues could productively be viewed as school-wide rather than individual concerns. But there were traps in the strategy she chose for doing this, which were obvious to other administrators. In particular, one administrator noted that in this scenario, it was the principal who chose which issues the sharing would be about, and that the principal had already decided which group of teachers would share first. This raised the question, Whose agenda was being explored?

> [Does] the faculty perceive that the principal really is interested in the sharing of practice, with an invitation for colleagues to comment, or [does] the faculty perceive the principal is really trying to get out there maybe some of his or her favorite things, or desired things? There's a tension that gets created. I've seen this happen over and over again....
>
> I know the kind of tensions that get created for the other faculty that are listening and they're perceiving that the principal is recognizing a certain group of teachers' work in a different kind of way.... I've seen it happen over and over again with principals... with the best intentions of wanting to share something.

In the discussion that followed, the administrators examined issues of power and authority in the school. In this administrator-generated scenario, the principal has the power to define which were the important problems for everyone to work on (the principal picks the battles). The principal also might have a preferred solution to the problem. Further, this view is informed by a transmission view of learning—things that work are transmitted from one teacher to others.

Another understanding of the process by which ideas move around in a school was quite different. Here, the movement of ideas is driven by real questions that everyone cares about, and the role of the principal is to nurture and encourage inquiry. As one administrator put it,

> I think you have to nurture the process of inquiry every step along the way, too. Just like for kids, you have to model what you believe. And the way the principal can help that process along is to ask inquiring questions, real questions that you want to hear real puzzlings about, and not have a set agenda.

In this administrator's view, the entire culture of the school needs to be characterized by an orientation toward inquiry.

> I think part of it is developing a culture within the school [such] that the staff meeting is a place where you can ponder as well as pass out information or solve problems.... I think it's the whole culture of the school that needs to somehow be a culture of inquiry.... the discussions all along the way have to be discussions not of solutions but of real questions, so that you begin to break down that notion of the principal as the one who [has the] answers. Because at least with my staff, they've got so many ideas that they just need to know that they can be heard.

A second administrator in the group agreed, pointing out that a culture of inquiry, supported at the building level by the principal, also sends the message to teachers that open-ended inquiry needs to be taking place in classrooms, too:

> I think that's a very important point. And I think probably if you could build the ideal thing [it would be] that teachers would reflect that in their classrooms. In other words, it wouldn't just be among the faculty that we had this notion of inquiry.... [T]eachers would [change toward inquiry in instruction. They would] understand that page after page doesn't work here.

The first administrator went on to say that cultivating a culture of inquiry in the school is a responsibility of the principal. In her view, although the rhetoric of inquiry might sound laissez-faire, real change in classrooms needs to happen; the principal is responsible for providing the leadership to get new models of teaching and working together to become realities in schools:

> I also think that inquiring people find real, concrete steps to take. I think sometimes it sounds so loosey-goosey that it sounds like we're just going to ask questions. I believe we have to do things for children that are different, and change our thinking. But I guess as a profession we tend to fall into linear ways of thinking and hierarchical ways of thinking. And I guess it's for the leadership to keep trying to get out of that model. To some extent. The buck still stops with us.

In this snippet of dialogue, administrators were exploring a role for themselves—as the askers of questions, the legitimatizers of teachers' inquiry as well as students'—in a school culture built on the assumption that everyone is intellectually generative. According to this view, it is important for authentic inquiry to occur both in classrooms and among teachers throughout the school—and one type of inquiry supports the other. "If you could build the ideal thing,... teachers would reflect that in their classrooms... teachers would... understand that page after page doesn't work here." Thus, principals still have power and authority, but they use it differently. They use it to legitimize questioning by others rather than to conduct everyone to a predetermined solution.

Not only did the administrators' views of learning influence their picture of how new ideas move around in a school and how to foster such movement, they also influenced the degree to which administrators saw teachers' learning itself as a process that requires empathetic colleagues. The administrators explored "critical colleagueship" (Lord, 1994) as an image for teachers' and their own professional development. They understood "critical colleagueship" as an ongoing relationship among teachers, involving commitment to helping each other improve their teaching and their thinking about teaching. "Critical colleagues" would empathize with each other but would also be committed to providing each other with constructive criticism.

Administrators' underlying image of learning influenced their thinking about what kind of mutual help critical colleagues can provide. If learning is seen as a relatively unproblematic process of acquiring new skills, then critical colleagues are those who provide feedback and assist with teaching technique. This point of view was revealed in a conversation about peer coaching:

> Is there a difference between critical colleagueship and peer coaching?... when teachers go into one another's classrooms, observe what's going on, and... then [discuss] what the observing teacher saw, what kinds of questions were asked by the kids as well as by the teacher...

Project staff pointed out that, according to Lord's (1994) definition, "critical colleagueship" refers to a relationship in which teachers challenge each others' underlying beliefs, while "peer coaching" implies a context in which teachers help each other implement practices consistent with their current beliefs. The administrator who asked the question did not see the distinction, and interpreted "challenging underlying beliefs" to mean that teachers need to acknowledge their own shortcomings. She went on to say that teachers can receive feedback from others as well as from colleagues:

> But also, there are other ways that people can confront their own shortcomings.... That is, you don't necessarily have to be working in a group of colleagues and discussing it. One of them is to talk with the supervisor, and to build a relationship with that person, and, again, you have to be open to it, but to have someone come in and observe and give feedback and help, and do those kinds of things. That can work. That can help a person change, and maybe that can get the person ready for something else.

On the other hand, if an administrator viewed learning as driven by internal questions, essentially as a process of conceptual change entailing uncertainty and risk, then "critical colleagues" provide both the stimulation for rethinking one's practice as well as emotional support during the process. Several administrators expressed this in their definitions of critical colleagueship:

> In critical colleagueship, teachers define their own issues from their own experience.... The prevailing view is a menu-driven, external definition of questions and issues.

> I thought that in critical colleagueship, it allowed for uncertainty and questioning, and coming to some judgment on the part of the teacher. In the prevailing view there's sort of delivering the answers to teachers.

> I think critical colleagueship, has to do with intense listening to other people—and teachers really don't get that sense, that any of us listen, as a whole, I think. The bureaucrats don't listen, or principals don't listen, or whatever.

These administrators also saw that critical colleagueship has implications for how ideas move around in schools. They realized that shifting the culture of the school so that it supports critical colleagueship is a way of putting ideas at the center of organizational life, and requires building in the collegiality, empathy, and sense of joint enterprise that ongoing intellectual work depends on.

The administrators began to brainstorm about how critical colleagueship could be created in a given school or district. Once again, there were several views on this, influenced by the administrators' own ideas about the nature of learning itself. One frustrated administrator wanted the inquiry-group reading material to tell her how to create critical colleagueship, despite recognizing that method as not the most reliable way to learn:

> I wanted [the article] to come with a laundry list of how I should do it. I didn't want the model to be for me to come up with how to do it, you know. I want to know how I can have this happen more in my town... and in a way I did want those bad quick fixes, cause I want to get it done.

Another suggested that they examine their inquiry group itself for ideas about the roles of community and commitment to each other in supporting the examination of practice:

> But I'm trying to think about what it means to *be collegial*. For example, this group, in part, represents an effort at collegiality. And, I think [we could do] some reflection on what personally that has meant as a way to really understand.

Picking up this thread of the conversation, another administrator described the characteristics of the community that had been created in the administrators' inquiry group:

> I feel that we are intellectual colleagues here.... I feel that we're kind of tacitly agreeing to deal with difficult questions in a very open way, here. And I think that's remarkable. And I will contrast that with numerous meetings that I have attended this year... They have not at all met the level of the... dialogue that we've been engaged in [here]. I think [they've] been extraordinarily simple, I think [they've] been trivial, actually.

Another administrator noted that it was not only the intellectual depth of the discussion and authenticity of the issues that had been discussed, but the sense of commitment to work together that had made the examination of their own practice possible:

> I think there's also something to be said about the development of the "groupness." It would be interesting to have someone join the group at this point, because over the last two years, we really actually have grown into this relationship with each other. We certainly didn't start there, and I think there's something to be said for where we've been as a group in that process.... I don't know exactly how much time we've spent together, but it feels like enough that it's more than just intellectual and, while we haven't visited each other, I think there's enough, there's been enough personal sharing and enough interaction that we really know each other in that professional sense.

In examining the nature of the inquiry group in which they had participated, these administrators recognized the contributions to open-minded examination of difficult professional issues made by their own membership in the group over time. They expressed the commitment they had made to each other to think hard and talk honestly about important problems, and appreciated the trust that had developed among group members. And they specifically understood that similar conditions would support teachers' exploration of new ideas about mathematics, learning, and teaching.

So, Will Administrators' Behavior Change?

As we have seen, administrators' own ideas about the nature of mathematical knowledge, learning and teaching, and the intellectual culture of schools, served as lenses through which they viewed elements of the mathematics education reform movement and which disposed them to act in certain ways. During the life of the inquiry group, these administrators examined a variety of images of mathematical knowledge and explored how those visions affected their work with parents; they discussed the

nature of environments that support deep mathematical and pedagogical learning on the part of teachers; they argued about whether or not professional development for teachers needs to help them wrestle with fundamental beliefs about teaching and learning; and they investigated how new ideas can be made to move around in a school, what the nature of collegial school environments might be, and the extent of their own responsibility in providing leadership for school change. And they realized that they could use their experience in the inquiry group as an ongoing reference for continuing to think about these things. In each of these pursuits, their own views of the nature of mathematics and learning significantly affected their interpretation of the situation and what they thought could or should happen.

Most administrators' understanding of the nature of learning and teaching evolved over the course of the inquiry group; some of their ideas changed substantially. But were these changes reflected in behavior? Did administrators begin to act differently in their daily work, reflecting the development of their new interpretive lenses? Did they begin to build a different intellectual culture in their schools and districts?

The answers to these questions are complex. Changes in conceptual understanding and in behavior are iterative—through new lenses one can see others' and one's own behavior differently, and then act differently. When one acts differently, others respond to the new situation created by this new behavior, and then there is a new group of actions to be interpreted through the new lenses. The nature of the changes in administrative behavior that will result as administrators begin to reflect—in their behavior—their newly emerging set of lenses on the nature of mathematics, learning and teaching, and the intellectual culture of school, is an empirical question. We do not yet know how their roles will change, which collective norms will begin to evolve, or what policies and practices will begin to shift. Until administrators have had the time to consider some of the fundamental ideas that undergird their practice, and make some moves toward changing that practice, it will not be clear what a new administrative practice would look like. But we can begin to see the shape of such a new practice by looking at those aspects of their practice that administrators choose to change.

During the course of the inquiry group, one administrator observed that, while he had developed many new ideas about learning and teaching, his own behavior had not changed. For example, he saw that implementing the Massachusetts State Frameworks in his district would require a shift in fundamental beliefs about the nature of learning and teaching on the part of many teachers and administrators, but that these educators did not yet appreciate that. They were interpreting the Frameworks through the old, familiar "transmission lens" on learning, rather than seeing that the Frameworks represent a different set of conceptual lenses on learning altogether. Perceiving the new lenses would require reconceptualizing their practice:

> What I hear people saying is that we have to align our curriculum with the Frameworks. But if there's anything the Frameworks are not about, it's alignment.... People are taking "guiding principles," "strands," "concepts,"... and saying, well they will work or they won't work. They're good or they're not good. Because of how they shape up in terms of the prevailing view. There's no consciousness about taking what we do and comparing it to the Frameworks.

He went on to say that he now understood that there was a new role that he needed to learn to play. He needed to learn how to help people think deeply about their assumptions about learning and teaching, so that working with the Frameworks would become an opportunity for transforming the basic premises about learning and teaching upon which education in his district was based:

> And I don't know how to teach people to do that yet. And what [the article on critical colleagueship] has helped me to do is to struggle with my own misstep in not helping people in leadership roles to step out in front and to ask people to look at the Frameworks differently. Or their own practice differently.... I don't know how to have people step into the Frameworks and... imagine what our instruction might be like and imagine what teaching might be like.... So this article churned up a lot in me.

As he searched for an explanation for why he had not yet acted on this ambitious agenda in a

way that met his expectations for himself, he observed that his ideas had changed, but his behavior hadn't caught up:

> I think I'm getting to sense why. Because maybe my prevailing view is such that I can't get out of it either. I think I'm in my mind in one view and in my behavior in the other.... I mean, my behavior isn't there.

This administrator saw that ideas and behavior are linked in complex ways, and that though his ideas about reform had been changing over the course of the inquiry group, he had not yet had the opportunity to develop the administrative practices that his new ideas implied. And he saw quite specifically what he needed to learn to do: help others in his district shift their fundamental beliefs about the nature of mathematics, learning, and teaching in order to view the educational enterprise through new lenses.

Staff conducted a consultancy with this administrator during the following year, in which he worked on changing his practice in the context of leading his district's elementary mathematics curriculum-selection process. Analogous to classroom visitations with teachers, consultancies provide a context in which individual administrators and project staff together examine the conceptual underpinnings of some aspect of the administrator's current practice. The consultancy supports administrators in viewing daily tasks through new conceptual lenses, reflecting on what they see, and considering how they might act in light of new insights. This administrator realized that he could treat the process of curriculum selection as an opportunity to develop a vision for elementary mathematics with the participating teachers and parents, rather than as the relatively mechanical process of evaluating texts against a list of criteria. He redesigned the district's selection process so that it provided the opportunity for exploration and investigation of each curriculum's mathematics and pedagogy. His district chose a far more progressive curriculum than it would probably have chosen in the past, and the teachers who participated in the selection process reported that it engaged them in important ideas far more than did the typical selection process.

Conclusion

In this paper I have argued that if mathematics education reform is to become a permanent feature of school life, the intellectual culture of schools as a whole will need to change, as well as the instructional practices of many individual teachers. Since the need to change school culture necessarily leads to a focus on school and district administrators, I have suggested that administrators bring to the reform setting a variety of well-formed ideas about mathematics, learning, teaching, and the intellectual culture of schools; these ideas influence both how they interpret the goals of the mathematics education reform movement and what they think they should do to support that movement. Reformers need to take into account the power and function of these ideas: for many administrators—as well as for many teachers—the project of change may involve deep examination of prior ideas and beliefs about the nature of learning, teaching, and mathematical knowledge, as well as reconceptualization of practice on the basis of new ideas.

In an effort to explore what it would mean for school administrators—elementary school principals, district mathematics supervisors, and assistant superintendents for curriculum and instruction—to reflect on their own ideas, the Mathematics for Tomorrow project conducted a monthly seminar in which administrators thought deeply about the nature of mathematical knowledge, the process by which teachers come to transform their teaching practice, the way new ideas can be made to move around a school or district and their own role in that process, and the prospect of making change in their own administrative practice.

Administrators had many interesting ideas about these matters; some of these were informed by older, "transmission"-oriented ideas of pedagogy, while others were informed by progressive notions, in which change comes from inside the individual and can be "unlocked" and "supported" by the environment. Their interpretations of the intent of the mathematics education reform movement and their ideas about effective action they might take were

significantly influenced by their underlying ideas about the nature of mathematics and of learning itself. Over time, in discussion with each other and with project facilitators, these administrators explored the implications of their ideas about mathematics, learning, teaching, and school culture. In the discourse, which was designed to uncover some core assumptions, a number of administrators began to shift their own thinking about these matters and to engage with the issue of how their new understandings would link to their professional practice.

To date, the mathematics education reform movement has focused on the ideas of children and, to a growing extent, of teachers. In these domains it has been shown that simply providing new information about mathematics, or learning, will not be sufficient to support and encourage new behavior. Rather, both children and teachers need well-structured opportunities to investigate the efficacy of the ideas that they bring to the enterprise and to reconstruct the conceptual landscape when necessary. I have argued in this paper that it is important to expect the same of administrators, and to provide similar opportunities to them for conceptual reconstruction.

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Appendix

Mathematics for Tomorrow Syllabus for Administrators' Inquiry Group, 1994–1995

November 3, 1994

Discussion of "Kathy: A Case of Innovative Mathematics Teaching in a Multicultural Classroom" by G. Williamson McDiarmid, in J. Kleinfeld (Ed.), *Teaching Cases in Cross-Cultural Education*. College of Rural Alaska, University of Alaska, Fairbanks. 1992.

December 6, 1994

Discussion of an issue from administrative practice: supporting professional development in a complex task environment.

January 9, 1995

Continued discussion of "Kathy: A Case of Innovative Mathematics Teaching in a Multicultural Classroom."

February 7, 1995

Discussion of district plans for alternate assessment. Case presented by Claire Jackson, Assistant Superintendent, Brookline Public Schools.

March 7, 1995

Discussion of a school's plans for alternative assessment. Case presented by Lynn Stuart, Principal, Cambridgeport School, Cambridge.

April 10, 1995

Discussion of "All Aboard?", a case of collaboration for school-wide change. Developed by Education Development Center, Inc., and the Los Angeles Educational Partnership. 1993.

May 2, 1995

Discussion of "Teachers' Professional Development: Critical Colleagueship and the Role of Professional Communities" by Brian Lord, in N. Cobb (Ed.), *The Future of Education: Perspectives on National Standards in America*. New York: The College Board. 1994.

June 12, 1995

Discussion of participants' papers. Presentations about mathematics education made to their respective School Committees.

Notes

[1] Mathematics for Tomorrow is a four-year program of two, two-year cycles, each with a separate group of teachers and some new administrators. This paper describes work undertaken in the first program cycle.

[2] There was no systematic difference between the ideas about mathematics, learning and teaching held by principals and those held by district-level administrators. However, whether an administrator was a building principal or worked in a central office did sometimes affect the specific content of a practical example that illustrated the ideas. For example, in the context of talking about parents' concerns, a principal would be more likely than a district-level administrator to talk about his/her ideas in the context of planning or attending a parents' night at the school, while a district-level administrator would be more likely to talk in terms of parents' presence at school committee meetings.

References

Carpenter, T. P. (1985). Learning to add and subtract: An exercise in problem solving. In Silver, E. A. (Ed.), *Teaching and Learning Mathematical Problem Solving: Multiple Research Perspectives*. Hillsdale, NJ: Lawrence Erlbaum.

Carpenter, T. P., Fennema, E., Peterson, P., & Carey, D. (1988). Teachers' pedagogical content knowledge of students' problem-solving in elementary arithmetic. *Journal for Research in Mathematics Education* 19, 385–401.

Cohen, D. K. (1995). Teaching Practice: Plus ça change... In Jackson, P. (Ed.), *Contribution to Educational Change: Perspectives on Research and Practice* (pp. 27–84). Berkeley, CA: McCutcheon.

Cuban, L. (1984). *How Teachers Taught: Constancy and Change in American Classrooms 1890–1980*. New York: Longman.

Elmore, R. F. (1996). Getting to scale with good educational practice. *Harvard Educational Review* 66 (1), 1–26.

Elmore, R. F., & McLaughlin, M. W. (1988). *Steady Work: Policy, Practice, and the Reform of American Education*. Santa Monica, CA: The RAND Corporation.

Fennema, E., Carpenter, T., & Loef, M. (1993). Learning to use children's mathematical thinking: A case study. In Maher, C., & Davis, R. (Eds.), *Relating Schools to Reality*. Boston: Allyn & Bacon.

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (in press). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*.

Fennema, E., & Nelson, B. S. (1997). *Mathematics Teachers in Transition*. Mahwah, NJ: Lawrence Erlbaum.

Franke, M. L., Fennema, E., & Carpenter, T. P. (1997). Teachers creating change: Examining evolving beliefs and classroom practice. In Fennema, E., & Nelson, B. S. (Eds.), *Mathematics Teachers in Transition*. Mahwah, NJ: Lawrence Erlbaum.

Fullan, M. (1993). *Change Forces: Probing the Depths of Educational Reform*. New York: Falmer Press.

Goldsmith, L.T., & Schifter, D. (in press). Understanding teachers in transition. In Fennema, E., & Nelson, B. S. (Eds.), *Mathematics Teachers in Transition*. Mahwah, NJ: Lawrence Erlbaum.

Lampert, M. (1987). Teachers' thinking about students' thinking about geometry: The effects of new teaching goals. Cambridge, MA: Educational Technology Center, Harvard Graduate School of Education, Issue Paper TR-88-1.

Lord, B. T. (1994). Teachers' professional development: Critical colleagueship and the role of professional communities. In Cobb, N. (Ed.), *The Future of Education: Perspectives on National Standards in America*. New York: College Entrance Examination Board.

Murphy, J. (1994). Transformational change and the evolving role of the principal: Early empirical evidence. In Murphy, J., & Seashore, K. (Eds.), *Reshaping the Principalship: Insights from Transformational Reform Efforts*. Thousand Oaks, CA: Corwin Press.

Murphy, J., & Seashore, K. (1994). *Reshaping the Principalship: Insights from Transformational Reform Efforts*. Thousand Oaks, CA: Corwin Press.

NCTM (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: National Council of Teachers of Mathematics.

NCTM (1991). *Professional Standards for Teaching Mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Nelson, B. S., & Hammerman, J. K. (1996). Reconceptualizing teaching: Moving toward the creation of intellectual communities of students, teachers, and teacher educators. In McLaughlin, M. W., & Oberman, I. (Eds.), *Teacher Learning: New Policies, New Practices*. (pp. 3–21) New York: Teachers College Press.

Nolan, J. and Francis, P. (1992). Changing perspectives in curriculum and instruction. In *Supervision in Transition: The 1992 ASCD Yearbook*. Reston, VA: Association of Supervision and Curriculum Development.

Nussbaum, M. (1990). *Love's Knowledge: Essays in Philosophy and Literature*. Oxford, England: Oxford University Press.

Schifter, D. & Fosnot, C.T. (1993). *Reinventing Mathematics Education: Stories of Teachers Meeting the Challenge of Reform*. New York: Teachers College Press.

Schifter, D., & Simon, M. S. (1992). Assessing teachers' development of a constructivist view of mathematics learning. *Teaching and Teacher Education* 8(2), 187–197.

Shroyer, J., & Fitzgerald, W. (1986). *Mouse and Elephant: Measuring Growth*. Menlo Park, CA: Addison Wesley.

Thompson, A.G., (1991). The development of teachers' conceptions of mathematics teaching. Paper presented at the annual meetings of the International Group for the Psychology of Mathematics Education, Blacksburg, VA.

Tyack, D. & Tobin, W. (1994). The "grammar" of schooling: Why has it been so hard to change? *American Educational Research Journal* 31, 453–479.

Wasley, P, (1991). Stirring the chalkdust: Changing practices in essential schools. *Teachers College Record* 93, 28–58.

Wood, T., Cobb, P., & Yackel, E. (1991). Change in teaching mathematics: A case study. *American Educational Research Journal* 28 (3), 587–616.

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Barbara Scott Nelson is Senior Scientist and Director of the Center for the Development of Teaching at Education Development Center, Inc. She holds the B.A. degree in philosophy from Mt. Holyoke College, the MAT from Johns Hopkins, and the Ed.D. from Harvard University. She has long been interested in the relationship between teachers' ideas about learning, teaching, and subject matter, and the particular social and intellectual contexts in which their teaching is embedded. The Mathematics for Tomorrow project, which she directs, looks at the systemic implications of a mathematics teacher-enhancement program based on a constructivist view of teachers' intellectual development. Currently, she is working with school- and district-level administrators on the implications of mathematics education reform for the intellectual culture of schools and for their own work.